

TITLE OF THE INVENTION

COMMUNICATION SYSTEM, GATEWAY EQUIPMENT,  
COMMUNICATION METHOD AND AUTHENTICATION METHOD

5 BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a mobile  
communication system and relates in particular to a mobile  
communication system, gateway equipment, communication  
10 method and mobile terminal authentication method for mobile  
IP protocol.

Description of Related Art

Much intense study of IP (Internet Protocol) for  
mobile communication networks has been made in recent years.

15 The IETF (Internet Engineering Task Force) is working  
on standardized Mobile IPv6 specifications (for example, in  
non-patent document 1; Mobility Support in IPv6  
<draft-ietf-mobileip-ipv6-19.txt>, Work in Progress).

The elements comprising the Mobile IPv6 network  
20 structure are a Mobile Node (MN), a home agent (HA), and a  
correspondent node (CN).

An IP address (home address serving as identification  
information for the mobile node) is assigned to the MN. This  
IP address does not change even when the MN moves. A link  
25 having the same prefix as the home address is called the home

link. The HA manages MN location information (Binding Cache) located other than in the home link.

When the MN moves to a link (host link) other than the home link (foreign link), the MN acquires the IP address of that link. This address is called the Care of Address (CoA). The MN receives a router advertisement sent periodically by the router in the foreign link. The MN senses movement by detecting a prefix different from the home address.

When the MN detects movement, it registers the location in the HA. The MN contains a Home Agent Address Discovery function capable of dynamically searching for home agent IP addresses.

The MN creates a Mobile IPv6 Home-Agents Anycast Address from the prefix of the home link. The MN sends an ICMP Home Agent Address Discovery Request to that address. That ICMP Home Agent Address Discovery Request signal is sent to the HA in each of the home links. The HA that received the ICMP Home Agent Address Discovery Request sends an ICMP Home Agent Address Discovery Reply containing HA information to the MN. The MN acquires the address of the HA by extracting HA information from the ICMP Home Agent Address Discovery Reply signal. The MN makes a binding update (performs location registration) of the HA address it acquired.

When the HA receives the binding update, it retains the MN home address and the CoA binding information in the binding cache. The HA next acts as a proxy (on behalf) of the MN, sending a Gratuitous Neighbor Advertisement to  
5 capture packets addressed to the home address of the MN.

The CN (correspondent node) is a peer node with which a MN is communicating.

The procedure used by the CN for sending a packet addressed to the MN is described next.

10 The CN sends a packet addressed to the MN home address. The HA that received the packet addressed to the MN home address, searches the binding cache, and acquires the CoA matching the MN home address. The HA attaches an IP header for the received packet and sends the encapsulated packet.  
15 The Destination Address of the external header is a CoA.

When the CoA addressed packet is received, the MN first removes (decapsulizes) the IP header that was attached and restores the original packet.

The home network might reattach a prefix. The Mobile  
20 IPv6 contains a function to notify the MN of the host network of prefix information for the home network. The HA checks the binding cache and notifies the MN in the binding update process with an MPA (Mobile Prefix Advertisement).

Technology for localized management of mobile  
25 communication based on Mobile IPv6 has been proposed (for

example, in non-patent document 2; Hierarchical Mobile IPv6  
mobility management (HMIPv6)

<draft-ietf-mobileip-hmipv6-07.txt> Work in Progress).

The MPIIPv6 contains a MAP (Mobile Anchor Point)  
5 between the HA and MN. The MAP provides that network with  
a local HA function. The MAP may also contain an AR (access  
router) under its control. The MN receives a router  
advertisement from the AR containing a MAP option, and  
acquires the IP address of the MAP. The MAP option contains  
10 the global address of the MAP, the MAP prefix, the MAP  
preference, and the number of hops to the MAP, etc. The MAP  
uses either of the following methods to notify the AR of MAP  
options.

(1) MAP distributes a router advertisement containing  
15 MAP options to the router (AR).

(2) MAP expands the router renumbering function for  
IPv6 and notifies the AR of the MAP options.

Instead of the MAP informing the AR of the MAP options,  
the network manager may set the MAP option information in  
20 the AR.

The information with the MAP options is stored when  
a MN compatible with HMIPv6 standards receives the router  
advertisement containing the MAP options. The MN  
(compatible with HMIPv6) generates a RCoA (Regional Core of  
25 Address) from the MAP prefix contained in the MAP option and

the MN interface identifier. The MN also generates an LCoA (on-link CoA) utilizing prefix information contained in the router advertisement. The LCoA is equivalent to the CoA of the Mobile IPv6.

5           The (HMIPv6 compatible) MN first of all makes a binding update (location registration) on the MAP. The MAP manages the binding information along with the RCoA and LCoA of the MN. The binding update signal that the MN sends to the MAP contains bits showing the MAP binding update  
10   (registration information). The MN next performs the binding update in the HA. The HA manages the MN home address and the RCoA of the binding information. When the MN has moved within the MAP, the MN rewrites only the MAP location information.

15           The IPv6 address is specified in RFC2373. Three types of addresses; unicast, anycast and multicast are defined as IPv6 addresses. The unicast address contains three types (global address, site local address, and link local address) of addresses. The site local address can only be used within  
20   the site and is equivalent to an IPv4 private address (for example non-patent document 3).

          The IPv6 Prefix Delegation Options for DHCPv6 (DHCP-PD) are also being evaluated. Here, DHCP-PD is a function that makes use of DHCP (Dynamic Host Configuration

Protocol) to assign IPv6 prefix (group) to sites from the side handling address assignment.

The delegating router and requesting router are the elements that make up the DHCP-PD. The requesting router  
5 makes a request to the delegating router to assign an IPv6 prefix (group). The delegating router selects an IPv6 prefix (group) and sends that prefix to the requesting router. This DHCP-PD is used for example by ISP (Internet Service Providers) when assigning a prefix to subscribers  
10 (as for example in non-patent document 4).

[Non-patent document 1]

D. Johnson and others, Mobility Support in IPv6, [online], October 29, 2002, Internet <URL:  
http://www.ietf.org/internet-drafts/draft-ietf-mobileip-  
15 ipv6-19.txt>

[Non-patent document 2]

Claude Castelluccia and others, Hierarchical Mobile IPv6 mobility management (HMIPv6), [online], October 2002, Internet <URL:  
20 http://www.ietf.org/internet-drafts/draft-ietf-mobileip-hmipv6-07.txt>

[Non-patent document 3]

R. Hinden and others, IP Version 6 Addressing Architecture, [online], July 1988, Internet <URL:  
25 http://www.ietf.org/rfc/rfc2373.txt>

[Non-patent document 4]

O. Troan and others, IPv6 Prefix Options for DHCPv6,  
[online], November 27, 2002, Internet <URL:  
http://www.ietf.org/internet-drafts/draft-ietf-dhc-dhcpv  
5 6-opt-prefix-delegation-01.txt>

The zone A and zone B are mutually connected and when  
a mobile node (MN) belonging to zone A has moved to zone B,  
the HA holding the location information (binding cache) for  
mobile nodes in zone A functions as a proxy for the MN.

10 The zone A and the zone B utilize site local addresses  
so a conflict might arise between the MN home address and  
the visited network address.

The Mobile IPv6 ensures the arrival of communications  
at the home address by supplying a permanent IP address (home  
15 address) to the MN that does not change even if the MN moves  
its location. The MN user can change the network settings  
containing the IP address if the MN is a personal computer,  
etc. However, when the home address of the MN is changed  
(rewritten), the problem arises that the arrival of  
20 communications at the MN cannot be guaranteed. Methods  
allowing the MN to acquire the home address have been  
considered in order to resolve this problem. However,  
Mobile IPv6 does not contain a function to dynamically  
assign home addresses to the MN.

The Mobile IPv6 prefix discovery function is provided to the MN registering the location information (binding update) in the HA. So prior to making the binding update (location registration), the MN cannot receive the signal  
5 (MPA) notifying it of home network prefix information.

#### SUMMARY OF THE INVENTION

The present invention has the object of providing a mobile communication method capable of allowing the MN to  
10 acquire the home address in the visited network. The present invention in particular has the object of providing a mobile communications method for distributing home address prefix information to a mobile terminal X by utilizing the DHCP-PD function, when the home network of the mobile terminal X with  
15 an HA belonging to zone A has moved to zone B.

The present invention has the further object of providing a mobile communication method for a mobile terminal X not performing a binding update (location registration) in the HA, to acquire home address prefix  
20 information in zone B.

The present invention has the still further object of providing a mobile communication method to send functions and information required for distributing home address prefix information to a mobile terminal from a network



management equipment via HA and gateway equipment of zone B.

The present invention has the yet further object of providing a mobile communication method for starting authentication processing and DHCP-PD functions for the binding update signal the MN sends to the MAP, when the gateway equipment of zone B is an HMIPv6 compatible MAP. A yet further object is to provide a highly safe mobile terminal communication method by having the MAP accept only the binding update request of the MN whose results from authentication processing were approved by the MAP.

The present invention is a communication system comprising a home network installed with a home agent for holding mobile terminal location information and, a visited network installed with a radio communications device for communicating with that mobile terminal, and gateway equipment in the visited network for forming an interface with the home network, wherein the radio communication device contains an access request transfer means for forwarding access requests from a mobile terminal of the visited network to the gateway equipment, and the gateway equipment makes an acquisition request to the home agent for an identifier of that mobile terminal, and forwards that acquired identifier to that mobile terminal.

The present invention is in other words characterized in comprising the following means.

(1) The home agent (HA) contains a means for reporting (notifying) prefix information to a gateway equipment  
5 containing a DHCP-PD requesting router function and further contains a delegating router function for the DHCPv6 Prefix Delegation Option (DHCP-PD).

(2) The gateway equipment (GW) belonging to the visited network contains a DHCP-PD requesting router  
10 function and an authentication function. The gateway equipment contains a means for requesting the sending of authentication information on a packet transmission source when the gateway equipment receives packets from an un-authenticated transmission source; a means for sending  
15 the authentication request to the authentication server when an authentication request is received from the mobile terminal (MN); and a means for requesting distribution of prefix information to an HA containing a DHCP-PD function when determined from the authentication results that the  
20 mobile terminal is authentic; and a means to notify the mobile terminal with prefix information when prefix information was received from the HA.

(3) The HA and gateway equipment (GW) further contain a means for receiving the DHCP-PD function described in (1)  
25 and (2) from the network management equipment.

(4) The gateway equipment (MAP) may instead contain a means to request distribution of prefix information to the HA when the gateway equipment receives a binding update request from the MN if the gateway equipment contains an  
5 HMIPv6 compatible MAP function.

(5) The gateway equipment (MAP) may instead contain a means to approve the binding update only for authenticated MN if the gateway equipment contains an HMIPv6 compatible MAP function.

10       The present invention is a communication system comprising a home network installed with a home agent for holding mobile terminal location information and, a visited network installed with a radio communications device for communicating with that mobile terminal, and gateway  
15 equipment in the visited network for forming an interface with the home network, wherein the radio communication device contains an access request transfer means for forwarding access requests from a mobile terminal of the visited network to the gateway equipment, and the gateway  
20 equipment makes an acquisition request to the home agent for an identifier of that mobile terminal, and forwards that acquired identifier to that mobile terminal so that the mobile terminal can acquire the home address in networks (visited networks) other than the home network.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a structural view of the communication network of the first embodiment of the present invention;

FIG. 2 is a block diagram of the home agent (HA) of  
5 the first embodiment of the present invention;

FIG. 3 is a drawing showing the structure of the binding cache management table contained in the home agent (HA) of the first embodiment of the present invention;

FIG. 4 is a drawing showing the structure of the prefix  
10 management table contained in the home agent (HA) of the first embodiment of the present invention;

FIG. 5 is a block diagram of the gateway equipment (GW) of the first embodiment of the present invention;

FIG. 6 is a drawing showing the structure of the prefix  
15 management table contained in the gateway equipment (GW) of the first embodiment of the present invention;

FIG. 7 is a drawing showing the structure of the acceptable IP address list contained in the gateway equipment (GW) of the first embodiment of the present  
20 invention;

FIG. 8 is a drawing showing the structure of the zone file contained in the DNS server of the first embodiment of the present invention;

FIG. 9 is a drawing showing the sequence of the binding update processing of the first embodiment of the present invention;

FIG. 10 is a flowchart of the authentication  
5 processing routine of the gateway equipment (GW) of the first embodiment of the present invention;

FIG. 11 is a flowchart of the prefix request processing of the gateway equipment (GW) of the first embodiment of the present invention;

10 FIG. 12 is a flowchart of the prefix delegation processing routine of the first embodiment of the present invention;

FIG. 13 is a drawing showing the format of the IPv6 packet of the first embodiment of the present invention;

15 FIG. 14 is a drawing showing the format of the DHCPv6 packet of the first embodiment of the present invention;

FIG. 15 is a drawing showing the IA\_PD options format of the first embodiment of the present invention;

FIG. 16 is a drawing showing the IA\_PD prefix options  
20 format of the first embodiment of the present invention;

FIG. 17 is a drawing showing the Home Agent Address Discovery Request message format of the first embodiment;

FIG. 18 is a drawing showing the Home Agent Address Discovery Reply message format of the first embodiment;

FIG. 19 is a drawing showing the Binding Update message format of the first embodiment;

FIG. 20 is a drawing showing the Binding Acknowledgment message format of the first embodiment;

5        FIG. 21 is a diagram showing the structure of the communication network of the second embodiment of the present invention;

FIG. 22 is a block diagram of the home agent (HA) of the second embodiment of the present invention;

10       FIG. 23 is a block diagram of the gateway equipment (GW) of the second embodiment of the present invention;

FIG. 24 is an illustrative drawing showing the structure of the communication network of the third embodiment of the present invention

15       FIG. 25 is a block diagram of the gateway equipment (MAP) of the third embodiment of the present invention;

FIG. 26 is a sequence diagram of the binding update processing routine of the third embodiment of the present invention;

20       FIG. 27 is a sequence diagram of the binding update processing routine of the fourth embodiment of the present invention; and

FIG. 28 is a flowchart of the prefix request processing for the MAP of the fourth embodiment of the  
25    present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiment of the present invention is described next while referring to the accompanying drawings. The method for acquiring the home address when the Mobile  
5 IPv6-compatible node (MN) has moved to a network (hereafter visited network) other than the home link (hereafter home network) is described in detail as an example.

FIG. 1 is a drawing showing the structure of the communication network of the first embodiment.

10 The communication network is comprised of an MN3 home network 6, and IP network 7 and a visited network 5 (5a, 5b). In the first embodiment, the home network 6, the IP network 7 and the visited network 5 are an IPv6 network. The MN3 is a mobile node (MN) compatible with Mobile IPv6. The  
15 visited network 5 and the IP network 7 are connected by way of gateway equipment (or routers) functioning as connection devices. The IP network 7 and the home network 6 are connected by way of routers (or gateway equipment). The visited network 5 and the home network 6 may also be  
20 connected by way of routers or gateway equipment.

The home network 6 is comprised of HA 1 and a DNS server 10. The visited network 5 (5a, 5b) is comprised of a radio communications device (access point) connected to MN3, a router 4 (4a, 4b), and a gateway equipment 2 (2a, 2b)  
25 functioning as an interface between the visited network 5

and the IP network 7. The IP network 7 is comprised of an authentication server 8. The gateway equipment 2 and the authentication server 8 may be directly connected.

Here, the HA 1 is a home agent (HA) compatible with Mobile IPv6. The HA1 manages the location information other than in the home network 6. The HA1 contains a function to supplement the packet addressed to the MN3 home address that was sent by the other communication terminal (CN) 9, and to forward the packet to the MN3 present within the visited network 5b. The DNS server 10 for example, replies with an IP address to the domain name of NM3 sent from the CN9.

FIG. 2 is a block diagram showing the structure of the home agent (HA) 1 installed in the home network 6.

The HA1 is comprised of an interface section (IF) 19 (19a, 19b, 19m, 19n) containing a server section 11 (11a, 11b), server section 12, and line 18 (18a, 18b, 18m, 18n) as well as a switching section 17 (17a, 17b).

The server section 11 is comprised of a packet send-receive processing section 13, an encapsulation-decapsulation processing section 14, and a Mobile IP processing section 15.

The packet send-receive processing section 13 contains a function to send or receive data packets. The encapsulation-decapsulation processing section 14 contains a function to add or delete the IP header from the data



packet. The Mobile IP processing section 15 has a home agent (HA) function for Mobile IPv6 and contains a binding cache management table 330 (FIG. 3).

The server section 12 contains the packet  
5 send-receive processing section 13 and DHCP-PD function section 16. The DHCP-PD function section 16 is comprised of a delegating router function for DHCP-PD, contains a prefix management table 310 (FIG. 4) and executes the prefix delegation processing routine 80 (FIG. 12).

10 FIG. 3 is a drawing showing the structure of the binding cache management table.

The binding cache management table 330 matches at least a Care of Address (CoA) 332 acquired in the visited network by MN3 and a lifetime 333 showing the effective  
15 period of the binding cache with the MN3 home address 331 and stores them (332 and 333).

FIG. 4 is a drawing showing the structure of the prefix management table 310. The prefix management table 310 matches at least an IAID 312 showing the prefix (group), and  
20 a distributed prefix 313, and a lifetime (effective period) 314 of the distributed prefix with the DHCP Client identifier 311 and stores them (312, 313, 314).

FIG. 5 is a block diagram of the gateway equipment (GW)  
2 installed in the visited network 5.

The gateway equipment 2 is comprised of an interface section (IF) 23 (23a, 23b) containing a CPU 21, a memory 22, and a line 24 (24a, 24b) mutually connected to a bus 25.

The memory 22 contains a DHCP-PD function section 26  
5 and an authentication processing section 27. The DHCP-PD function section 26 has a requesting router function for the DHCP-PD, contains a prefix management table 320 (FIG. 6) and executes a prefix request processing routine 60 (FIG. 11). The authentication processing section 27 contains an  
10 acceptable IP address list 340 (FIG. 7) and executes an authentication processing routine 70 (FIG. 10).

FIG. 6 is a drawing showing the structure of the prefix management table 320.

The prefix management table 320 matches the  
15 distributed prefix 323, the lifetime (effective period) 324 of the distributed prefix, and the DHCP server identifier 325, with the IAID322 showing the IA\_PD321 prefix (group) in the gateway equipment 2 and stores them (323, 324, 325).

FIG. 7 is a drawing showing the table structure of the  
20 acceptable IP address list 340.

The acceptable IP address list 340 matches the authenticated IP address 341 and the IP address 342 installed in the authentication processing 27 of gateway equipment 2 and stores them (341 and 342).

The structure of the DNS server is described next. The DNS server 10 is comprised of a CPU, a memory, a storage section for storing a zone file (FIG. 8) and an interface section connected to a network (home network 6).

5        FIG. 8 is a drawing showing the structure of the zone file 350 contained in the storage (memory) section of the DNS server. The zone file 350 stores the FQDN (Fully Qualified Domain Name) 351, and the IP address 352 corresponding to that domain name. If there request is made  
10    to the DNS server for an IP address via the domain name, the DNS server searches the zone file 350 and replies with an IP address matching that domain name. A node that acquired a new IP address can add the new entry by making a request to the DNS server 10.

15        FIG. 9 is a drawing showing the sequence from the MN3 in the visited network 5b creating a home address shown in FIG. 5, to the completion of the binding update processing.

      The MN3 receives (101) the router advertisement from router 4c belonging to the network 5b. The MN3 searches the  
20    M bit of the router advertisement and sets the method for acquiring the CoA (Care of Address). In other words, if the M bit of the router advertisement is set to 1, then the MN3 acquires the CoA by using the IPv6 statefull address autoconfiguration. If the M bit of the router advertisement

is not set, then the MN3 acquires the CoA by using the IPv6 stateless address autoconfiguration (102).

The MN3 sends the CoA acquired in the visited network 5b to the IP packet that was set in the source IP address (103). This IP packet is conveyed via the gateway equipment (GW) 2b. The gateway equipment 2b searches the acceptable address list 340 using the source IP address (CoA). If an entry for that CoA is not present in the acceptable address list 340, then a request to send authentication information to source IP address of the packet (104).

The MN3 that received the authentication information sends an authentication request containing the requested information (ID, password, etc.) to the gateway equipment 2b (105). The gateway equipment 2b performs the authentication processing routine 70 when the authentication request is received (See FIG. 10.).

The gateway equipment 2b then sends an authentication request to the authentication server 8 (106). The authentication server 8 authenticates the user (107). If the authentication was a success then a user home network identifier is included in that authentication reply.

The gateway equipment 2 that received the authentication reply 108 executes the prefix request processing routine 60 (See FIG. 11.). The gateway equipment 2b creates a prefix and an IA\_PD showing the correspondence,

from the home network identifier. The gateway equipment 2 sends a DHCP Solicit message addressed to All\_DHCP\_Relay\_Agents\_and\_Servers address to discover a DHCP server capable of distributing the prefix (109). This solicit message contains a Client Identifier Option for gateway equipment 2b and IA\_PD options. The IA\_PD options are set in that IAID.

The server section 12 of the HA1 that received the DHCP solicit message (109), starts the Prefix Delegation processing routine 80 (FIG. 12), and sends a DHCP advertise message to the gateway equipment 2b (110).

The gateway equipment 2b receives the DHCP advertise message (110). A check is then made that the IA\_PD options and client identifier option of the received message contain correct values and that the server identifier option is included in the received message.

The gateway equipment 2 then sends a DHCP request message containing the IA\_PD options to that server section 12 in order to request distribution of an IPv6 prefix (111).

The IPv6 prefix to be distributed is designated when the server section 12 of the HA1 that received the DHCP solicit message is capable of distributing the prefix to the IAID contained in the IAID file of the IA\_PD options. When that request message contains IA\_PD prefix options in the IA\_PD options, the server section 12 searches the IPv6

prefix field and approves the prefix that the gateway 2b wishes to use.

The server section 12 next searches DHCP Client identifier and IAID contained in that DHCP request message  
5 and the prefix management table 310 in the IAID. The server section 12 detects the entry created in step 82. The server section 12 then sends a DHCP reply message to the gateway equipment 2b (112).

The gateway equipment 2 checks that the Client  
10 Identifier option, IA\_PD options and Server Identifier option contain appropriate values when that DHCP reply message is received. The gateway equipment 2 then creates a new entry in the acceptable address list 340, and sends an authentication replay containing prefix information to  
15 MN3 (113).

In step 74, when a send authentication request to authentication server message containing an error notice from the prefix request processing routine is received, the gateway equipment 2b sends an authentication reply  
20 containing the error notification to MN3 (77) and this routine then ends.

When the MN3 receives an authentication reply containing prefix information, the MN3 creates a home address from the prefix information that was received and  
25 from the interface identifier (114).

The MN3 next sends a Home Agent Address Discovery Request for designating the IP address of the HA (115).

The MN3 sets the CoA acquired in step 102, into the (transmit) source address 41a of the home agent address discovery request message S11 (See FIG. 17.). The MN3 sets the prefix received in step 113 as the home network prefix for the Mobile IPv6 Home-Agents Anycast Address, into the destination address 41b of the home agent address discovery request message S11.

10 Any HA having the same prefix as that Mobile IPv6 Home-Agents Anycast Address, receives the home agent address discovery request.

The server section of HA1 here stores a prefix identical to the prefix of the Mobile IPv6 Home-Agents Anycast Address and receives the Home Agent Address Discovery Request. The server section 11a sends a Home Agent Address Discovery Reply to MN3 (116).

The server section of HA1 stores the following values in the Home Agent Address Discovery Reply message (FIG. 18) to send to the MN3. The HA address (HA list) is stored in the Home Agent Addresses field of IPv6 ICMP411. The source address for the Home Agent Address Discovery Request is set in the destination address 41b. The global unicast address for the server section 11a is set in the (transmit) source address 41a.

The MN3 acquires the HA address from the Home Agent Address Discovery Reply (117). The MN3 first of all, checks whether or not the source address of the Home Agent Address Discovery Reply is in the HA address (HA list). If the source  
5 address is contained in the HA list then the MN3 performs a binding update (location registration) for addresses recorded in the HA list. If the source address is not contained in the HA list then the MN3 performs a binding update of the source address.

10 The HA list for this Home Agent Address Discovery Reply does not contain a source address. The MN3 performs the binding update (location registration) in the server section 11a of HA1.

The MN3 sends the binding update message to the server  
15 section 11a of HA1 (118). The MN3 temporarily records the server section 11a address in the binding update list management table (119).

The following values are stored as shown in FIG. 19 when MN3 sends the binding update to the server section 11a.  
20 The CoA of MN3 is set in the source address 41a of the IPv6 header. The home address created by MN3 in step 114 is set in the home address field of the IPv6 Destination Options Header 401.

The server section 11a of HA1 receives the binding  
25 update message and extracts the home address contained in



the Pv6 Destination Options Header 401. The server section 11a searches the binding cache management table 330 to find if that home address entry is present. If that MN3 entry is not found in the binding cache management table 330, then  
5 the MN3 entry is added to the binding cache management table 330 (120). The MN3 sets the CoA acquired in the visited network 5b into the Care of Address 332 of that entry. The server section 11a functions as a proxy for the MN3.

The server section 11a sends a binding acknowledgment  
10 to the MN3 (121). The binding acknowledgment that the server section 11a sends to the MN3 is stored as the following values as shown in FIG. 20. The (transmit) source address of the binding update received in step 118 is stored in the destination address 41b of the IPv6 packet header. The MN3  
15 home address is stored in the home address field of the IPv6 routing header 403 when storing the values other than the MN3 home address in the destination address 41b.

When a binding acknowledgment is received showing that the binding update ended correctly, the MN3 registers  
20 the entry temporarily stored in step 119, into the binding update list management table (122).

The MN3 may at this point also register the identification information (for example, FQDN) and corresponding information for the home address acquired in  
25 step 114, into the location information management device

(for example, DNS server) belonging to the home network 6, visited network 5 or the IP network 7.

The processing in the gateway equipment 2b from 106 through 113 in FIG. 9 is described next. FIG. 10 is a flowchart of the authentication processing routine 70. This authentication process is implemented in the authentication processing section 27.

The gateway equipment 2b sends an authentication request to the authentication server 8 (106 in FIG. 9 and 71). The authentication server 8 sends the authentication results to the gateway equipment 2b (108 in FIG. 9). If authentication was successful, then the home network identifier of the user is included in that authentication reply.

The gateway equipment 2b that received the authentication reply, searches the authentication results and determines if authentication was a success or not (72). If the authentication succeeded, the prefix request processing routine 60 (in FIG. 11) starts up (73). On the other hand, if the authentication in step 72 failed, then the gateway equipment 2b sends an authentication reply containing an error notice to the MN3 (77) and this routine then ends.

When an authentication reply transmit request containing the prefix is received from the prefix request

processing routine (74), a new entry is created in the acceptable address list 340 (FIG. 7) and the IP address (CoA of MN3) 341 and effective period 342 are then stored (75). The gateway equipment 2b sends an authentication reply  
5 containing prefix information to the MN3 (113 in FIG. 9, and 76) and this routine then ends.

However, when the gateway equipment 2b receives an authentication response request containing an error notice from the prefix request processing routine in step 74, the  
10 gateway equipment 2b sends an authentication response (77) containing an error notification to MN3 and this routine then ends.

The server section 12 may also use the DHCP Reply message (112 in FIG. 9) to notify the gateway equipment 2b  
15 with information such as the IP address of the DNS server 10. The gateway equipment 2b sends an authentication response containing information received from the server section 12 (76).

FIG. 11 is a flowchart of the prefix request  
20 processing routine 60. This routine is executed on DHCP-PD function section of the gateway equipment 2.

The gateway equipment 2b designates an IA\_PD linked with the prefix, from the home network identifier contained in the authentication request send from the authentication  
25 server 8. A DHCP Solicit message is sent addressed to

All\_DHCP\_Relay\_Agents\_and\_Servers addressed (109 of FIG. 9, 61). This solicit message contains a client identifier option for the gateway equipment 2 and an IA\_PD options (FIG. 15). The IA\_PD options (533 of FIG. 15) are set in that IAID.

5       The authentication processing section 27 of gateway equipment 2b is comprised of a user prefix management table (FIG. 4). This table may hold a user ID received in step 105 and information corresponding to the prefix information sent to MN3 in step 113.

10       The gateway equipment 2b receives the DHCP Advertise message and checks (110 in FIG. 9) that appropriate values are set in the IA\_PD options and Client Identifier option of the received message and contained in the Server Identifier option of the received message. The gateway  
15       equipment 2b next searches the prefix management table 320 (FIG. 6) for the IAID contained in the IA\_PD options of the DHCP Advertise message. If there is no applicable entry, the gateway equipment 2 creates a new entry in the prefix management table 320 and stores the DHCP Advertise message  
20       of the IAID and the identifier of the DHCP server. The gateway equipment 2 also stores home network identifier acquired in step 108 in IA\_PD321 (62).

      The gateway equipment 2 next sends a DHCP Request message containing IA\_PD options to the server section 12  
25       for requesting distribution of the IPv6 prefix (63, 111).

If the Advertise message received in step 110 is contained in the IA\_PD Prefix options (FIG. 16), then that Request message contains a prefix in IPv6 prefix field 535 of IA\_PD Prefix Options that the gateway equipment 2 wishes  
5 to use.

When the DHCP reply message is received, the gateway equipment 2 checks that the Client Identifier option, IA\_PD options and Server Identifier option have appropriate values (64). If the values are appropriate, the gateway  
10 equipment 2b searches the prefix management table 320 using the IAID and DHCP Server identifier contained in the DHCP replay message. The gateway equipment 2 detects the entry made in step 62, stores the IPv6 Prefix and lifetime of the prefix distributed to the applicable entry and rewrites the  
15 entry. After rewriting the applicable entry, the gateway equipment 2b requests (65) sending of an authentication reply containing IPv6 Prefix information from an authentication processing section 27 and this routine then ends.

20 However, when a DHCP advertisement containing appropriate parameters could not be received in step 62 or a DHCP reply message containing a prefix could not be received in step 64 (including when a DHCP reply message without the applicable entry was received in the prefix  
25 management table 320) the gateway equipment 2b requests (66)

an authentication reply containing an error notice from the authentication processing section 27, and this process ends.

The HA1 processing from 110 to 112 in FIG. 9 is  
5 described next.

FIG. 12 is a flowchart of the prefix delegation processing routine 80. The DHCP-PD function section 16 of HA1 executes this routine.

The server section 12 of HA1 that received the DHCP  
10 Solicit message, searches the IA\_PD file of IA\_PD options for the DHCP Solicit message. The server section 12 then decides whether or not a prefix can be distributed to the received IAID (81).

If the prefix can be distributed, the server section  
15 12 searches the DHCP client identifiers contained in the solicit message and the prefix management table 310 (FIG. 4). If there is no applicable entry, the server section 12 creates a new entry in the prefix management table 310 and stores the DHCP client identifier 311 contained in the  
20 solicit message and the IAID 312. The server section 12 then sends the DHCP advertise message to the gateway equipment 2b (110 of FIG. 9 and 82).

The advertise message contains an identifier for the server section 12 (Server Identifier option) and identifier  
25 for gateway equipment 2b (Client Identifier option) and the

IA\_PD option received in step 109. The server section 12 may also include IPv6 prefix information distributable to IAID, in the DHCP Advertise message. The IPv6 prefix information is set in IPv6 prefix field 535 of the IA\_PD options contained in the IA\_PD options 533 of the advertise message. The server section 12 designates a distributable IPv6 prefix using IAID.

When the server section 12 then receives the DHCP request message (111 of FIG. 9, and 83), it searches the IAID file of IA\_PD options. If the prefix can be distributed to IAID, then the server section 12 designates a distributable IPv6 prefix. When the request message contains IA\_PD prefix options in the IA\_PD options, the server section 12 searches the IPv6 prefix field and approves the prefix that the gateway equipment 2b wishes to use.

The server section 12 searches the DHCP client identifiers contained in the request message and the prefix management table 310 with IAID. The server section 12 detects the entry created in step 82 and stores the prefix Lifetime and IPv6 prefix distributable to the applicable entry. The server section 12 sends the DHCP reply message to the gateway equipment 2b (112 in FIG. 9 and 84) and this routine then ends. The reply message contains the IPv6 prefix information stored in the prefix management table 310 in the IA\_PD Prefix options field of IA\_PD options 533.

If the server section 12 cannot distribute the IPv6 Prefix to the IAID in step 81, then the server section 12 sends an advertise message containing a status code option showing the prefix cannot be distributed to the gateway  
5 equipment 2b, and this routine then ends (85).

When a prefix for distribution cannot be designated in step 83 or when there is no applicable entry in the prefix management table 310 in step 84, then the server section 12 sends a reply message containing error notice to the gateway  
10 equipment 2b (86) and this routine then ends).

FIG. 13 is a drawing showing the format of the IPv6 packet.

The source address 41a and the destination address 41b are contained in the IPv6 header 41. Information such as  
15 IPv6 path information can be stored in the extension header 42, and in this embodiment it can store the IPv6 destination options header 401 (FIG. 19), IPv6 mobility header 402 (FIG. 19, FIG. 20) and the IPv6 routing header 403 (FIG. 20). The DHCP message S1 (FIG. 14) can be stored in the payload 43.

20 FIG. 14 is a drawing showing the format containing the DHCPv6 message S1.

In the packet with DHCPv6 message, the DHCPv6 is an application protocol using UDP/IP in the transport layer. The DHCP message is specified by a value in the message type



field 51. The DHCP message option parameter is set in the options field 53.

FIG. 15 is a drawing showing the format of IA\_PD options S2.

5       The option code field 531 shows the type of DHCP message option parameter. The IAID is set in the IAID field 532. The IA\_PD Prefix options are included in the IA\_PD options 533.

FIG. 16 is a drawing showing format of the IA\_PD prefix  
10 options S3.

The IPv6 prefix field 536 contains prefix information capable of being distributed to the IAID.

FIG. 17 is a drawing showing the format of the Home Agent Address Discovery Request message S11.

15       The Home Agent Address Discovery Request message S11 is stored in the payload 43 of the IPv6 packet.

FIG. 18 is a drawing showing the format of the Home Agent Address Discovery Reply message S12. The Home Agent Address Discovery Reply message S12 is stored in the payload  
20 43 of the IPv6 packet.

FIG. 19 is a drawing showing the format of the Binding Update message S13. The IPv6 Destination Options Header 401 and IPv6 Mobility Header 402 are stored in the extension header 42 of the IPv6 packet.

FIG. 20 is a drawing showing the format of the Binding Acknowledgment message S14. The IPv6 Routing Header 403 and the IPv6 Mobility Header 402 are stored in the IPv6 packet extension header 42.

5           In the first embodiment of the present invention as described above, the HA1 and the gateway equipment contain a DHCP-PD function. The gateway device 2 starts this DHCP-PD function when the authentication request is received. The HA1 in other words, contains a means for distributing a  
10   prefix to the gateway equipment 2 belonging to visited network 5. Since this gateway equipment 2 belonging to visited network 5 contains a means to notify MN3 of the prefix, the gateway equipment 2 can therefore notify MN3 of the prefix information distributed from HA1 so that MN3  
15   outside the home network can acquire the home address.

          Since the MN3 contains a means to register identification information (for example, FQDN) and (mapping) information linked to the home address acquired in the visited network 5, in the DNS server, a call  
20   destination service can also be provided in the visited network 5 for MN3 that acquired a home address.

          The second embodiment of the present invention is described next. In addition to the first embodiment, the second embodiment is characterized in that the HA1 and

gateway device 2 receive programs from a network management equipment 31.

FIG. 21 is a diagram showing the structure of the communication network of the second embodiment.

5       The second embodiment has a network management equipment 31 in addition to the structure (FIG. 1) of the previously described first embodiment. This network management equipment 31 is connected to the HA1 and the gateway equipment 2. The network management equipment 31  
10       contains a means to send programs to the HA1 and the gateway equipment 2. The structure is the same as previously described for the first embodiment (FIG. 1) so identical reference numerals are assigned and a detailed description of those sections is omitted.

15       FIG. 22 is a block diagram of the structure of the home agent (HA) 1 of the second embodiment.

      In addition to the structure (FIG. 2) of the first embodiment, the HA1 contains a server section 32 having a management function section 33. In the present embodiment,  
20       the program and data used for the authentication operation are received from the network management equipment 31. Sections having the same structure as the first embodiment (FIG. 2) are assigned the same reference numerals and their detailed description is omitted here.

FIG. 23 is a block diagram of the gateway equipment (GW) 2 of the second embodiment of the present invention.

In addition to the structure (FIG. 5) of the first embodiment, the gateway device 2 contains a management  
5 function section 28 in a memory 22.

The HA1 and the gateway equipment 2 receive from the network management equipment 31, the respective programs and information needed for the prefix distribution shown in the first embodiment. The HA1 installs the received  
10 programs and information into the DHCP-PD function of the server section 12, and runs the applicable program with the DHCP-PD function section 16. The gateway device 2 installs the received programs and information into the DHCP-PD function 26 of the memory 22 and the authentication  
15 processing section 27, and runs the applicable program with the DHCP-PD function section 26 and the authentication processing section 27. Sections identical in structure to the first embodiment (FIG. 5) are assigned the same reference numerals and their detailed description is  
20 omitted here.

The second embodiment of the present invention as described above is comprised of a network management equipment 31 to provide the HA1 and the gateway equipment 2 with programs and data needed for notifying the MN3 of the  
25 prefix. Providing the HA1 and gateway equipment 2 with a

function to receive the applicable programs and data from the network management equipment 31 allows functions to be automatically installed and the authentication operation executed without having to install these functions

5    beforehand as was described for the first embodiment, and the functions of the mobile communication network (of the second embodiment) can easily be improved.

          The third embodiment of the present invention is described next. The third embodiment is characterized in  
10    that the gateway equipment 2 contains a MAP function for HMIPv6.

          FIG. 24 is a diagram showing the structure of the communication network of the third embodiment.

          The third embodiment differs from the above described  
15    structure (FIG. 1) of the first embodiment in that MN3 is a HMIPv6 mobile terminal and that the gateway equipment (MAP) 2 comprises a MAP function for HMIPv6. Sections identical in structure to the first embodiment (FIG. 1) are assigned the same reference numerals and their detailed  
20    description is omitted here.

          FIG. 25 is a block diagram showing the gateway equipment (MAP) 2 of the third embodiment.

          In addition to the structure (FIG. 5) of the first embodiment, the gateway device 2 contains an HMIPv6  
25    processing section 29 in the memory 22. This HMIPv6

processing section 29 provides a MAP function and contains a binding cache management table for holding information linked to the RCoA and LCoA. Sections identical in structure to the first embodiment (FIG. 5) are assigned the same reference numerals and their detailed description is omitted here.

FIG. 26 is a sequence diagram of the processing routine from the MN3 in the visited network 5b shown in FIG. 24 creating a home address, to the completion of the binding update (location registration) in the MAP2b.

The MN3 receives a router advertisement containing a MAP option from the router (AR: Access Router) 4c belonging to the network 5b (151). When the router advertisement containing the MAP option is received, the MN3 specifies the gateway equipment (MAP) 2b containing the HMIPv6 processing section 29, from the information contained in the MAP option. The MN3 next creates the RCoA and LCoA by using the information contained in the router advertisement MAP option (152).

The MN3 sends the binding update (location registration) signal showing the location registration to the MAP in the MAP 2b (153). The following information is stored in the binding update (location registration) signal. The LCoA created in step 152 by the MN3 is set in the source address 141a. The MAP2b address is set in the

destination address 41b. The RCoA created by the MN3 in step 152 is set in the home address option of the Destination Options Header 401.

5 The MAP2b that received the binding update (location registration) signal then starts the authentication processing. This MAP2b that received the binding update (location registration) signal, searches the acceptable IP address list 340 in the source IP address (LCoA). If there is no LCoA entry for the MN3 in the acceptable IP address  
10 list 340, then a request to send authorization information is sent (104) to the packet source (NN3). The processing from here onwards from step 104 to step 113 is the same as in the first embodiment (FIG. 9).

In the third embodiment, the MAP 2b adds an LCoA and  
15 RCoA for the MN3 to the acceptable IP address list 340 (FIG. 7).

If the authentication processing ends normally, then the binding information for the RCoA and LCoA of the MN3 is stored in the binding cache management table of HMIPv6  
20 processing section 29 (154). The MAP2b then sends the binding acknowledgment to the MN3 (155). A MAP 2b address is next set in the source address 41a of this binding acknowledgment. An LCoA for MN3 is set in the destination address 41b, and an RCoA for MN3 is set in the routing header  
25 403.

However, if the authentication processing does not end normally, then the MAP2b sends a binding acknowledgment containing an error notification to the MN3 (155).

If a binding acknowledgment (155) was received  
5 showing that the binding update (location registration) ended normally, then a home address is created from the prefix information received in step 113 and the MN3 interface identifier (114). The processing from here onwards from step 114 to step 122 is the same as in the first  
10 embodiment (FIG. 9).

The MN3 registers the home address created in step 114 and the RCoA binding information created in step 152, into the HA1. The source address 41a of the binding update 118 is set based on the MAP option contained in the router  
15 advertisement received by the MN3 in step 151. If the binding update 118 source address 41a is not the RCoA, then the RCoA is set in the Alternate-CoA option of binding update 118.

In the third embodiment of the present invention as  
20 described above, the HA1 and the gateway equipment contain a DHCP-PD function. The gateway equipment 2 contains an HMIPv6 MAP function. The gateway equipment 2 starts the MN authentication processing when an HMIPv6 binding update (location registration) signal is received, sends a prefix  
25 distribution request to the HA, and requests the sending of



authentication information. The gateway equipment 2 can therefore start up the DHCP-PD function when the authentication request signal is received, and can notify the MN3 of the prefix information distributed from HA1.  
5 Those MN3 located outside of the home network can therefore acquire the home address.

The gateway equipment 2 comprising the HMIPv6 function only permits binding update (location registration) of MN3 whose authentication processing ended  
10 normally so a highly safe communication service can be provided.

The fourth embodiment of the present invention is described next. The fourth embodiment is characterized in that the MN3 acquires home network prefix information in the  
15 binding update (location registration) response message from the gateway equipment 2. In other words, the DHCP-PD function section 26 of the gateway equipment 2 executes the prefix request processing routine 90 (FIG. 28) instead of the prefix request processing routine 60 (FIG. 11).

20 FIG. 27 is a sequence diagram of the processing routine from the MN3 in the visited network 5b shown in FIG. 24 creating a home address, to the completion of the binding update (location registration) in the MAP2b.

The processing from step 151 to step 152 are identical to the same steps in the previously described third embodiment (FIG. 26).

When the RCoA and LCoA are created, the MN3 sends a  
5 binding update (location registration) signal to the gateway equipment (MAP) 2b to show location registration in the MAP 2b (171). The binding update (171) is implemented so that the home network identifier of MN3 is contained in the Mobility Options of the Mobility Header 402.

10 The MAP2 that received the binding update, starts the prefix request processing routine 90 (FIG. 28).

FIG. 28 is a flowchart of the prefix request processing routine 90 of the fourth embodiment.

The MAP 2b specifies an IA\_PD showing a link to the  
15 prefix, from the home network identifier contained in the binding update 171, and creates the IAID. The MAP 2b sends a DHCP solicit message addressed to

All\_DHCP\_Relay\_Agents\_and\_Servers in order to discover a DHCP server capable of prefix distribution (91, 109).

20 Hereafter, step 92 through step 94 (from step 110 to step 112 in FIG. 27) are performed by the same processing as in prefix request processing routine 60 of the first embodiment (from step 62 to step 64).

When a DHCP reply message (112) containing the prefix  
25 is received, and the MAP2b rewrites the applicable entry in

the prefix management table 320, it requests a binding acknowledgment containing IPv6 prefix information from the HMIPv6 processing section 29 (95), and this routine then ends (95). After the MAP2b stores the MN3 location

5 information in the binding cache management table (154), it sends a binding acknowledgment (172) to the MN3. The binding acknowledgment (172) is implemented so that the IPv6 prefix information is contained in Mobility Options of the Mobility Header 402.

10 On the other hand, when the processing in step 92 or step 94 did not end correctly, or in other words, when a DHCP advertise message containing the correct parameters could not be received in step 92, or when a DHCP replay message containing a prefix could not be received in step 94

15 (including the case where a DHCP reply message was received not having an applicable entry in the prefix management table 320); then the MAP2b sends a request (96) for sending of a binding acknowledgment containing an error notice to the HMIPv6 processing section 29 (96) and this routine then  
20 ends.

The processing from step 114 to step 122 are identical to the same steps in the previously described third embodiment.

In the fourth embodiment of the present invention as  
25 described above, the MAP2 starts the DHCP-PD function when

the binding update (location registration) signal is received, and the home network prefix of the MN3 can be acquired from the HA1.